ADJUSTABLE FORM

The present application claims priority to US provisional patent application serial number 60/446,481, which was filed February 11, 2003.

FIELD OF THE INVENTION

The invention relates to a form adapted for use in a metallurgical vessel and, more specifically, to a form for placing a refractory lining in such a vessel.

BACKGROUND OF THE INVENTION

The present invention describes an apparatus for forming a flowable refractory lining material on inside surfaces of a metallurgical vessel. Flowable materials include powder, granular, sprayable, gunnable and castable refractories. Commonly, flowable materials comprise refractory powder or granular refractory materials which, when mixed with water, are adapted for casting, ramming or spraying. Flowable materials also include any thixotropic material that fluidizes when vibrated but is otherwise solid. Thixotropy may depend on, for example, chemical composition, grain size distribution, water content, additives, etc.

Metallurgical vessels typically comprise a metal shell and a refractory lining on the inner surface of the metal shell. Such vessels are adapted to contain or receive a flow of molten metal, and include for example ladles, tundishes, furnaces, degassing vessels, and troughs.

The refractory lining along the inner surface must be applied at a minimum thickness or the integrity of the metal shell could be compromised. On the other hand, too thick a lining material is wasteful, expensive and decreases the capacity of the vessel. Producing an appropriate lining thickness often requires the use of a form placed within

the interior volume of the vessel. The form may even be manufactured specifically for a particular vessel.

The form may be used to apply a new lining or to repair or replace an old lining. Repair comprises applying a fresh refractory lining on the surface of an old lining. Replacement includes removing the old lining and forming a fresh refractory lining. In any case, installation of the lining on the inner surfaces of the vessel typically includes placing a form in the interior volume of the vessel so that the form and the inner surface define a space for the lining material. In a first method, the form is first placed into the interior volume of the vessel. The form and the inner surface define a space for receiving the flowable material. The flowable material is next placed within the space, thereby forming the lining. In a second method, the flowable material is first placed within the vessel and the form is pressed into the vessel. The flowable material conforms to the space created between the form and the inner surface of the vessel. In either process, the form may be removed from the vessel when the lining is sufficiently solid. Alternatively, the form may be fungible and retained in the vessel during casting. Of course, the production of the lining may also occur in a plurality of stages.

The prior art typically describes forms comprising a rigid apparatus having a defined geometry. The form is intended to be placed into a vessel regardless of the actual condition or geometry of the interior surface. For example, US 4,019,847 teaches a vibrating form that compacts the lining as the form is pressed down toward the inner surface of the vessel. The form comprises a defined shape. A refractory mix is first charged in the vessel and the weighted form is placed on the refractory mix and allowed to sink gradually into the vessel with vibration. Vibration fluidizes the refractory mix

and forces the mix into the space between the container and the form. The vibrating form forces the mix upward to fill the space. After vibration, the form is removed from the vessel, thereby forming a lining material within the vessel. Unfortunately, the spatial relationship between the vibrating form and the vessel is not well controlled, so that lining thickness can be inconsistent.

Frequently, a number of fixed forms are produced that can accommodate variations within a metallurgical vessel. This solution results in increased cost because of the number of forms, and increases the space needed to store and manipulate such forms. Alternatively, prior art forms may include adjustable panels. Flanges or fasteners on the panels permit dimensional change. The process includes disassembling the fasteners on the panels, manually spreading the flanges, installing shims to preserve the desired shape, and reassembling the fasteners. The confined space of the vessel's interior makes the fasteners on the panels awkward to reach, thereby making the adjustment procedure laborious and difficult. Further, the fasteners and flanges protrude beyond the panels so that their impressions can remain in the finished liner. This can make removal of the form difficult and can reduce the effectiveness of the lining. Given the difficulties with adjustable forms, manufacturers may sacrifice flexibility and opt for more than one fixed form.

The rigid forms of the prior art do not adjust for different geometries of the vessel or the interior surface. The resultant thickness of the lining material can be inconsistent, thereby creating significant waste or potentially dangerous conditions. Prior art adjustable forms include fasteners and flanges that are awkward to use, are exposed to the

lining, and can complicate removal of the form. The object of the present invention is to provide a lining apparatus, which overcomes the above defects.

SUMMARY OF THE PRESENT INVENTION

The present invention describes an apparatus adapted for use in creating a refractory lining in a metallurgical vessel. The apparatus includes a plurality of struts at least partially covered by a plurality of panels, which are secured to the struts. The panels define an exterior dimension of the apparatus.

The struts include at least one adjustable strut that permits adjustment of the exterior dimension of the apparatus. The adjustable strut comprises a first rib and a second rib adapted to move relative to the first rib. The panels are adapted to move relative to one another as the apparatus changes dimension. Conveniently and unlike the prior art, the panels require no fastener or flange outside the exterior dimension of the apparatus. In one embodiment, the panels are adapted to slide past each other as the adjustable strut is adjusted.

The struts are joined together by the panels or by a plurality of braces. Braces typically are oriented at substantially right angle to the struts. Conveniently, a combination of braces and struts produces a substructure onto which the panels may be secured.

In one embodiment, a connector slidably connects the first and second ribs of the adjustable strut, whereby the dimension of the adjustable strut can be adjusted. Preferably, the apparatus includes a plurality of adjustable struts.

In another embodiment, the substructure includes an adjustable brace between struts. The adjustable brace permits dimensional changes along a different axis than an

adjustable strut. Obviously, the adjustable brace may be combined with the adjustable strut.

The connector and adjustable brace may comprise any mechanical device that permits adjustment, including bolts, screws, rivets, etc. Welds and adhesives may also be used. Typically, the connector comprises an overlap of the strut's ribs. Holes in the region of overlap permit adjustment. The holes may be elongated to facilitate adjustment.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1. shows a side view along the length of the apparatus omitting side panels.

Fig. 2 shows a front view of a strut.

Fig. 3 shows an end of the apparatus, including end panels.

Fig. 4 shows a top view of a top connection between two ribs of a strut along G-G.

Fig. 5 shows a top view of a bottom connection between two ribs of a strut along H-H.

DETAILED DESCRIPTION OF THE INVENTION

The apparatus of the present invention comprises an adjustable form adapted for use in creating a refractory lining in a metallurgical vessel. The form includes a plurality of struts including at least one adjustable strut and a plurality of panels secured to the struts, thereby defining an exterior dimension of the form.

Panels may be secured directly to the struts or to a substructure comprising a plurality of struts and braces. Braces are oriented at substantially right angles to the struts. In either case, the panels move relative to one another as the adjustable strut is altered. Advantageously, the panels remain free of fasteners or other protrusions, thereby facilitating removal of the apparatus from the vessel after the lining has hardened.

Figure 1 shows a side view of one embodiment of the present invention. This embodiment is adapted for use in an elongated, generally rectangular vessel having two ends, such as a tundish. It should be appreciated that alternative versions of the current invention may also be used in vessels having cylindrical, hemispherical, or other non-rectangular shapes.

The apparatus 1 includes two ends 4 and a plurality of struts 2 along the length of the apparatus 1. The apparatus also includes end struts 3 at each end 4. A plurality of braces 6 is oriented along the length of the apparatus 1. The braces 6 join the struts 2 together, and the struts 2 and braces 6 define a substructure. The number and placement of struts and braces depends on, for example, the configuration of the vessel and mechanical requirements. Conveniently, the substructure substantially conforms to the vessels for which it would be used.

The braces are typically substantially perpendicular to the struts, but may include non-perpendicular struts 6a as desired or as demanded by the design. A brace comprises a member extending at least between adjacent struts. Preferably, the brace extends across a plurality of struts. The brace fixes the struts relative to one another. A brace may comprise an adjustable brace that permits alteration of the distance between at least two struts, thereby changing the length of the apparatus. The apparatus may include a plurality of braces having adjustable braces. In this manner, the adaptability of the substructure increases.

Figure 2 shows a strut 2 comprising a first rib 21a and a second rib 21b. The ribs 21 define an exterior perimeter between points BCDE. The points ABEF define a cover or lid 22 that is frequently used with the form. The lid 22 is adapted to insulate the vessel

during curing of the lining material. In actual practice, the lining material is often heated to at least about 700°F in order to speed the set of the lining material. The lid 22 retains the heat within interior volume of the vessel.

The ribs 21 may be fixedly secured relative to each other, but at least one strut 2 will include a connector 5. A connector 5 permits the ribs 21 on a strut to move relative to each other, thereby altering the exterior dimensions of the apparatus. The illustrated embodiment includes a top connector 5a and a bottom connector 5b. Alternative embodiments include, for example, a single connector, a single connector in combination with a hinge structure, or more than two connectors. Adjustment of a connector 5 varies the exterior perimeter of the strut 2 uniformly or non-uniformly. For example, expanding the bottom connector 5b without changing the top connector 5a would widen the bottom of the strut relative to the top. Alternatively, expanding both top and bottom connectors 5 simultaneously would widen, but would otherwise not affect, the relative dimensions of the exterior perimeter.

Connectors comprise any type of fastener that is capable of being unfastened and subsequent refastened by any means. Fasteners include bolts, screws, rivets, welds and adhesives. Conveniently, portions of each rib will overlap. Figures 4 and 5 show a bottom connector 41 and a top connector 51, respectively. The connectors typically comprise an overlapped portion 42. The overlapped portion 42 may be welded or glued together. Disadvantageously, welds and adhesives can be difficult to unfasten and may require specialized equipment or prolonged set times. Preferably, the connector will be mechanical. In one embodiment, the overlapped portion 42 includes at least one hole through each rib 21. The hole is adapted to receive a mechanical fastener 43. At least

one such rib 21 may include an elongated oval-shaped hole 44 that permits adjustment, that is, relative movement of the ribs 21 to each other. A bolt/washer combination can fixedly secure the ribs together. Alternatively, one rib may contain a tapped hole for a threaded bolt or screw. Rivets may also be used. Advantageously, bolts and screws are easily removable with common tools. Placement of the connector in the middle of the substructure permits an operator to have easy access for adjustment.

Panels cover at least a portion of the exterior perimeter of the struts and define the exterior dimensions of the apparatus. Panels typically include side panels and end panels. Optionally, one or more bottom panels may be present. The panels are fixedly secured, directly or indirectly, to the struts so that changes in the perimeter of the struts causes a change in the exterior dimension of the apparatus defined by the panels. Panels may accommodate such changes, for example, by overlapping one another along an adjustment axis. Overlapping panels provide for a small contact surface with the lining relative to prior art, which includes external protrusions, such as fasteners extending past the exterior volume. A small contact surface facilitates removal of the form after placement of a refractory lining in a metallurgical vessel. Elimination of external protrusion also reduces the potential for cracking in and premature wearing of the lining.

Figure 3 shows one embodiment of overlapping end panels 31. As the dimensions of the apparatus change, end panel 31b slides over end panel 31a. Notably, no protrusions or fasteners are present on the surface of the end panel 31. The overlapping panels preferably form a non-vertical lap joint, which slants toward the exterior perimeter. The outward slant allows the lap joint to avoid obstructions during removal of the apparatus from the vessel. Obstructions include hardened lining material

that protrudes into or above the joint. Vertical joint can be difficult to move past an obstruction. Obviously, an inward slanting joint would be even more difficult to remove and could require changing the dimension of the apparatus.

In practice, the apparatus is placed within the interior volume of a metallurgical vessel. Operators determine the thickness of a refractory lining that is desired at each position of the vessel. The operators loosen connectors and/or adjustable braces as needed. Ribs are expanded or contracted as desired. Length of the form changes by altering the spacing between struts. Panels correspondingly slide over each, thereby defining a new exterior dimension for the form. Connectors and adjustable braces are tightened or fixed, thereby fixing the new exterior dimension. The outer surface of the form and the inner surface of the vessel define a space in which a flowable material may be placed. After placement, the flowable material hardens and the form may be removed.

Conveniently, the adjustable form permits undercuts in the refractory lining. This can be important, for example, when the upper surface of the lining erodes more quickly than the lower surface. Slag floats on molten metal and is frequently more erosive/corrosive than the molten metal. The ability of the form to vary its width and length permits a non-fungible form to be used in undercut situations.

Obviously, numerous modifications and variations of the present invention are possible. It is, therefore, to be understood that within the scope of the following claims, the invention may be practiced otherwise than as specifically described.